National Park Service
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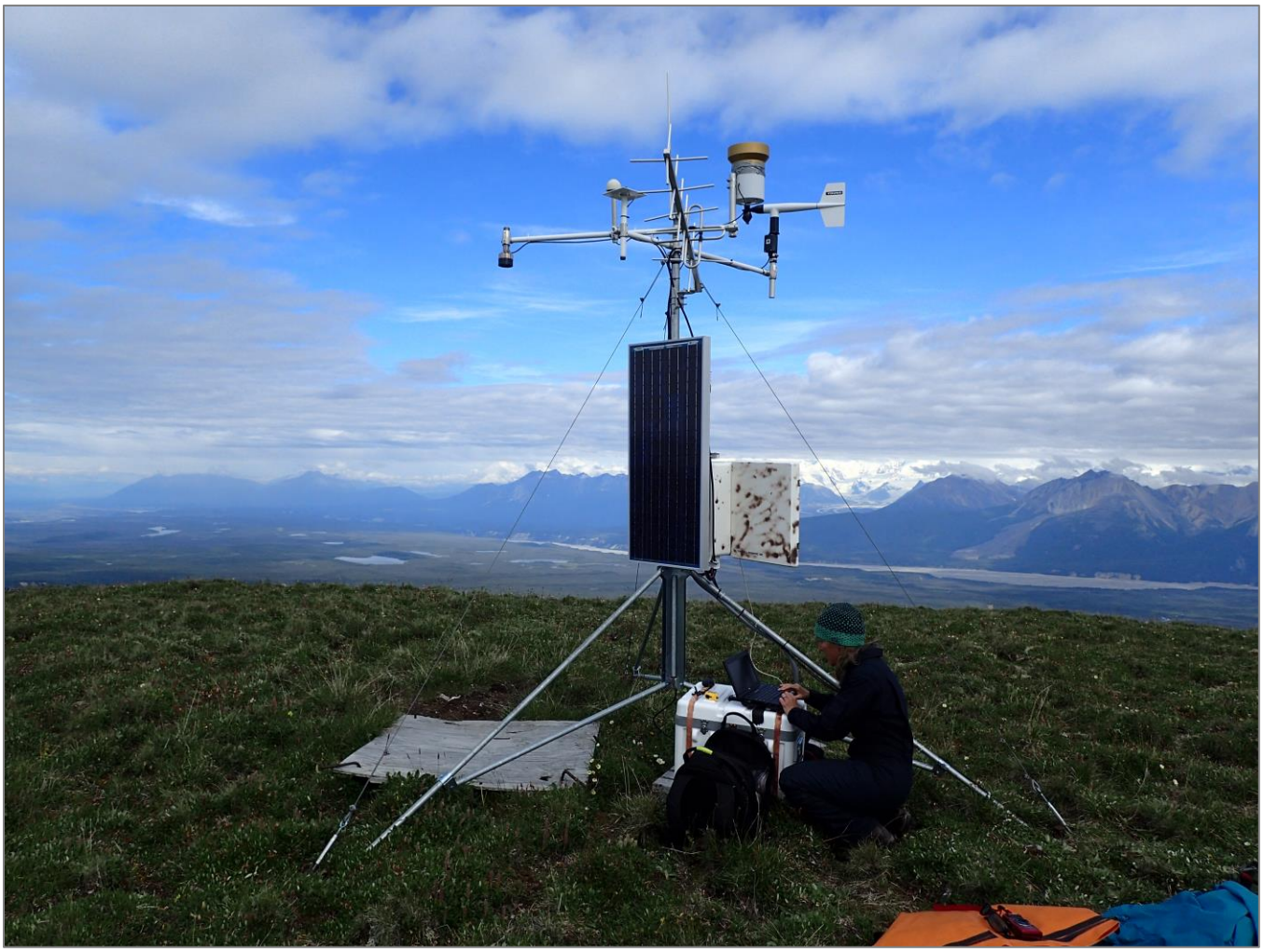
Natural Resource Stewardship and Science

Annual Climate Summary 2016

Central Alaska Network

Natural Resource Data Series NPS/CAKN/NRDS—2020/1260



ON THE COVER
Annual maintenance at Chititu climate station in Wrangell-St. Elias National Park and Preserve
NPS Photo by Ken Hill

Annual Climate Summary 2016

Central Alaska Network

Natural Resource Data Series NPS/CAKN/NRDS—2020/1260

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U.S. Department of the Interior
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Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Contents

Page

Figures....iv

Tables....v

Executive Summary....vi

Introduction....8

Central Alaska Network Climate Overview....8

Methods....9

Results....10

2016 Regional Climate Highlights:....10

2016 By the Numbers....11

Index Sites....11

CAKN RAWS Summary....12

2015-2016 Snow Season....15

Alaska Statewide Synopsis....19

Wildfire Activity....20

Climate Teleconnections....20

National and Global Synopsis....21

Conclusions....22

Literature Cited....23

Figures

Page

Figure 1. Map of climate and snow stations in the Central Alaska Network parks. vi

Figure 2. 2016 record warm year in Alaska 10

Figure3. Average monthly temperature departures (left) and monthly precipitation deviations (right). 11

Figure 4. Average annual temperatures (left) and precipitation deviations (right) at the CAKN index sites. 12

Figure 5. CAKN RAWS 2016 mean annual temperatures. 13

Figure 6. Trajectory of mean annual temperatures at three sites in the CAKN parks. 14

Figure 7. CAKN 2016 mean monthly temperatures. 14

Figure 8. Snow depth at Gates Glacier in WRST (left) and at Coal Creek in YUCH (right). 16

Figure 9. Snow depth at Chicken Creek/WRST (left) and Toklat/DENA (right). 16

Figure 10. Cumulative precipitation for water year 2016 at Kantishna (top) and Tokositna Valley (bottom) in DENA (NRCS 2017b). 17

Figure 11. Cumulative precipitation for water year 2016 at May Creek (top) and Chisana (bottom) in WRST (NRCS 2017b). 18

Figure 12. Cumulative precipitation for water year 2016 at American Creek near YUCH (NRCS 2017b). 19

Figure 13. Average temperature (left) and precipitation (right) ranks for Alaska in 2016 (NOAA 2017a). 19

Figure 14. March 1 and May 1 snowpack percent of normal for Alaska 2016 (NRCS 2017a). 20

Figure 15. PDO index through January 2017 (right) (JISAO, 2017) and Arctic sea ice extent 1978-2016 (left) (NSIDC 2017). 21

Tables

Page

Table 1. Summer rainfall totals at Denali and Wrangell-St. Elias 2016. 15

Executive Summary

The Central Alaska Network's climate monitoring program operates seventeen remote weather stations to monitor climate in Denali National Park and Preserve, Wrangell -St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve (Figure 1). The main goal of the program is to maintain these remote sites for the long-term in order to help scientists and park managers understand the climate patterns across these large parks. There are weather stations around the parks that are operated by various state and federal agencies that are used as index sites to compare current climate conditions in the region to the climatological normal - the average weather conditions over a 30-year period. The current normal period is 1981-2010. This report presents annual and monthly temperature and precipitation deviations for the index sites and monthly and annual statistics for NPS sites with shorter records. A brief synopsis of regional, national, and global climate conditions for 2016 is included for climatic context.

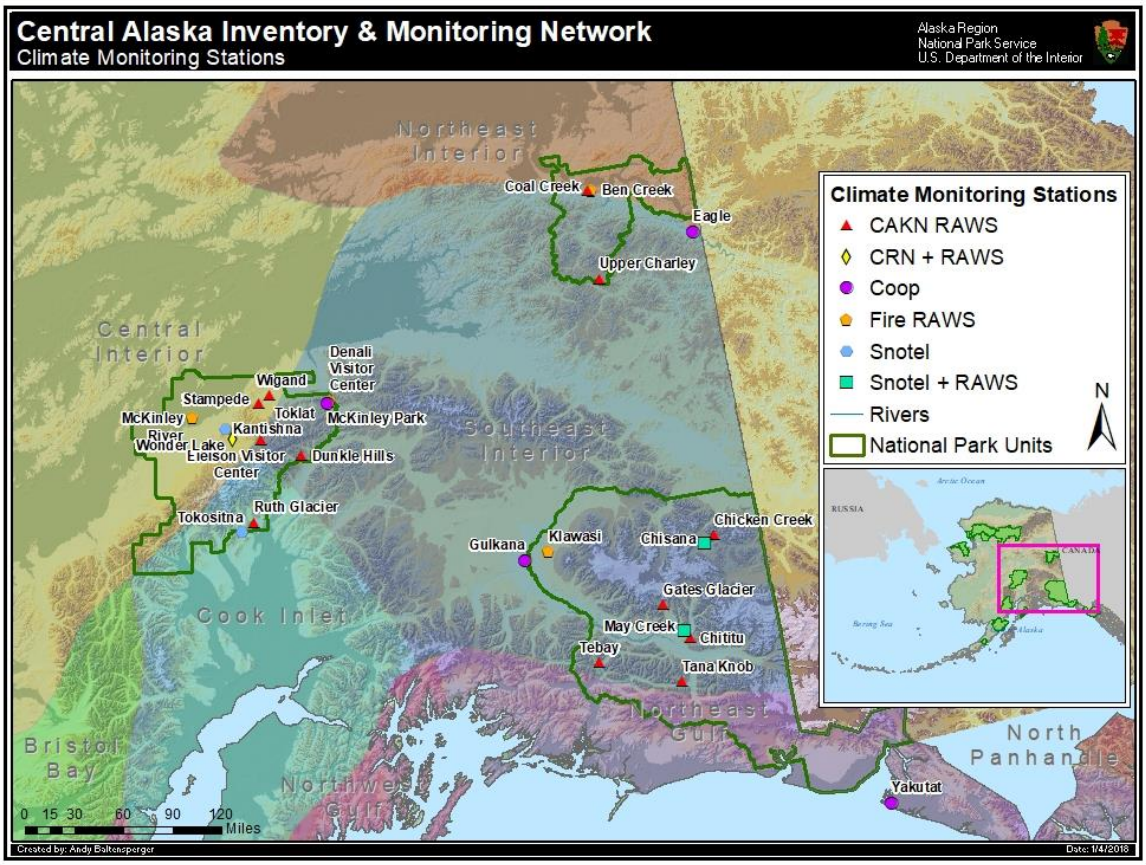

Figure 1. Map of climate and snow stations in the Central Alaska Network parks.

2016 was the warmest year on record for Alaska. It was the third year in a row with record temperatures for Alaska. The mean annual temperatures at the CAKN index sites were, on average,

3.6°F (2.0°C) warmer than the 1981-2010 normal. Annual precipitation totals across the CAKN region varied from 78% of normal in Yakutat to 114% of normal in Eagle and Denali Park headquarters.

During the summer of 2016, the Central Alaska Network staff conducted annual site maintenance at the thirteen CAKN climate stations, four snow telemetry sites, and assisted with maintenance of three fire weather stations. All of the 2016 CAKN RAWS weather data and corresponding metadata are available through the Integrated Resource Management Applications (IRMA) Data Store at https://irma.nps.gov/DataStore/Reference/Profile/2240059.

Introduction

Denali National Park and Preserve (DENA), Wrangell–St. Elias National Park and Preserve (WRST), and Yukon-Charley Rivers National Preserve (YUCH) make up the Central Alaska Inventory and Monitoring Network (CAKN), covering over 21 million acres. The network was established to monitor key components of ecosystems of the parks and to provide that information back to park managers for use in stewardship of park resources. Climate is considered to be one of the most important broad-scale factor influencing ecosystems and therefore the natural resources of parks. Because global climate models indicate that climate change and variability will be greatest at high latitudes, climate monitoring is critical to understanding the changing conditions of park ecosystems.

The 2016 field season marked the eighth year of operational climate monitoring in CAKN parks. Annual maintenance was performed at all of the climate stations. Maintenance at the climate sites included sensor replacement, troubleshooting, upgrades, data downloads, and sensor calibrations. Station maintenance logs were used to keep track of the climate station inventory for the stations. Sensor and power performance was tracked and instrumentation was replaced as necessary. A maintenance report is completed after each field season to document the details of the site visits – these reports include the field notes, photos, logistics, and sensor metadata (Hill and Sousanes 2018).

This is the 11th in a series of annual data reports that summarize the annual and monthly weather statistics for the CAKN climate monitoring program.

Central Alaska Network Climate Overview

The Central Alaska Network (CAKN) encompasses strong climate gradients, from the maritime climates in the southern parts of Wrangell – St. Elias National Park and Preserve (WRST) where it borders the North Pacific Ocean, to the strongly continental climates found in northern parts of Denali National Park and Preserve (DENA) and Yukon –Charley Rivers National Preserve (YUCH). The Central Alaska parks constitute parts of the Northeast Interior, Southeast Interior, Central Interior, and Cook Inlet Alaska climate divisions (Bieniek et al 2012). A transitional climate region lies between the coast and the interior influenced by major mountain ranges which act not only as the environmental controls to drive climate but also contribute to the highly localized micro climates found in complex mountain terrain. Redmond and Simeral (2006) provide a more detailed discussion of the climate of the Central Alaska Network.

The climate patterns of Alaska are primarily influenced by latitude, continentality, and elevation. Large scale atmospheric and oceanic circulation patterns influence seasonal and annual weather patterns in the state, like the repositioning of the polar jet stream and the Aleutian low pressure system, the frequency of La Niñas and El Niños and the seas surface temperature of the North Pacific Ocean as indicated by Pacific Decadal Oscillation (PDO) (Papineau 2001, Hartmann and Wendler 2005, Keen 2013). Each of these can affect the regional patterns of storm tracks, prevailing winds, snowfall amounts, and the extent of sea ice. In recent years there has been a continued significant reduction in the extent of the summer sea ice cover and the decrease in the amount of relatively older, thicker ice (NSIDC 2017). Models predict that retreating sea ice will affect the temperature and ecosystems of adjacent lands (Chapin et al. 2005).

Methods

There are five National Weather Service (NWS) stations in the CAKN region that have been in operation for 65 to 90 years that are used as index sites to place current year regional weather conditions into climatological context. Data were compiled from the index sites at McKinley Park and Talkeetna near/in DENA, Eagle near YUCH, and Gulkana and Yakutat near WRST. Monthly and annual temperature means and precipitation totals for 2016 are analyzed and compared with the 1981-2010 normal values for each site.

The CAKN climate monitoring program deployed 13 climate stations (CAKN RAWS) between 2004-2013 at mid-elevation sites to capture elevational and latitudinal climate gradients within the parks, and to capture data in areas where there were no baseline references. For detailed information on station locations, station design, and maintenance schedules see the CAKN climate monitoring protocols (Sousanes 2006). Monthly and annual means and totals were compiled for the climate variables measured at the CAKN RAWS, five additional fire RAWS, and five snow telemetry (SNOTEL) sites. The SNOTEL sites were analyzed by water year (October 1- September 30) for year-round precipitation and snowfall amounts. The CAKN data and metadata for 2016 are archived as discreet deliverables at https://irma.nps.gov/DataStore/Reference/Profile/2240059.

The summaries that are included in this report from NOAA and NRCS are in standard units; for consistency all data are presented in standard units.

Data Corrections and Data Quality Grading

Many stations operate under extreme environmental conditions which cause a variety of challenges. The most common problems are caused by wildlife and/or icing. Wildlife (usually bears), can damage sensors, cables, hardware, or the power supply. Icing can obstruct free-air movement on naturally aspirated radiation shields, build up on wind sensors, or block incident solar radiation sensors. Blowing snow or corrosion of snow depth transducers can lead to false snow depth measurements.

During the annual site visits data were downloaded from each CAKN climate station and checked for quality. CAKN station data, metadata, quality control flags/notes, and sensor history are managed with Aquatic Informatics Aquarius software and stored on the NPS Water Resources Division server in Fort Collins, Colorado. Errors or values outside a standard range were flagged and not were subsequently not used in the summary statistics. Details are logged in Aquarius and are also included in the annual maintenance report. For more information on the QA/QC process see the corresponding standard operating procedure (SOP) at https://irma.nps.gov/DataStore/Reference/Profile/2243700.

Results

2016 Regional Climate Highlights:

- 2016 was the warmest year on record for Alaska (Figure 2).

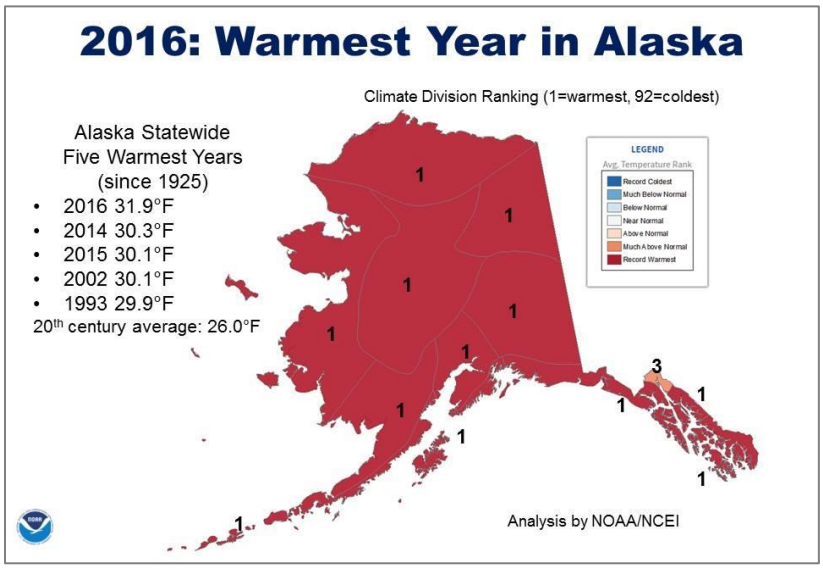

Figure 2. 2016 record warm year in Alaska

- In Denali, and for most of the central interior, fall of 2015 was one of the snowier falls on record, followed by a winter that was virtually snow-free. A total of 6.3 inches of snow fell between December 1 and February 29 at Denali Park headquarters, a new record low.
- There was a lack of very cold temperatures during the 2015-2016 winter season. According to Walsh et al. (2017) the 2015/16 cold season of Alaska was unprecedented in the historical record, which extends back nearly a century.
- It was the 2nd warmest winter on record for Eagle and Yakutat.
- Yakutat winter season snowfall (2015-2016) was very low for the second consecutive year. 2014-2015 was the lowest on record; this winter was the 4th lowest.
- A weather station at Kanuti (south of Bettles) recorded the lowest Alaskan temperature of the winter at -49°F. It is the first time on record that Alaska has not hit -50°F.
- It was a very warm spring region-wide. It was the warmest spring on record for Gulkana and Yakutat, the 2nd warmest on record for Denali, and the 3rd warmest for Eagle.
- It was the 2nd earliest break-up of the Yukon River at Eagle.
- The June 1 fire outlook was "normal" for upcoming season. The fire season, however, ended up well below normal. The total acreage burned in 2016 was slightly over half a million acres, which is about 25% below the 1996-2015 median.

- The warm trend continued in Yakutat – it was the warmest summer on record for the coastal town. It was the 4th warmest summer on record for Gulkana.
- July was a very wet month for Denali and Yukon-Charley and for most of the central interior region of Alaska. Summer rains at Denali: Toklat, Eielson Visitor Center, and Wonder Lake all reported the wettest summer in over a decade of measurements; mudslides closed the Denali park road.
- October was cold in Gulkana and Eagle. It was the coldest October in 20 years in Gulkana and the 4th coldest on record. Interestingly, It was much warmer than normal in Denali
- Yakutat is the wettest site of the first order stations in Alaska; it has highest annual precipitation and usually the high daily amount for the year. On September 12 it rained 3.74 inches which was the most of any site in a 24-hour period in 2016. Amazingly, there was no measureable precipitation in Yakutat from September 28 – October 15, which is statistically the wettest time of the year for that site. It resulted in the 3rd driest fall on record at Yakutat.
- October 2016 was the driest on record for Eagle.

2016 By the Numbers

Index Sites

In 2016, the mean annual temperatures at the five index sites around the CAKN parks averaged +3.6° F (2.0° C) warmer than the 1981-2010 normal. Figure 3 highlights that temperatures were warmest (larger positive deviation from normal) the first few months of 2016 coinciding with a strong El Niño, the Pacific 'blob' (very warm north Pacific Ocean temperatures), and a positive PDO. Every month in 2016 had warmer than normal temperatures, except for October and December. In December all of the sites were colder than normal. In October the eastern parks were colder than normal, but Denali temperatures persisted with warmer than normal temperatures.

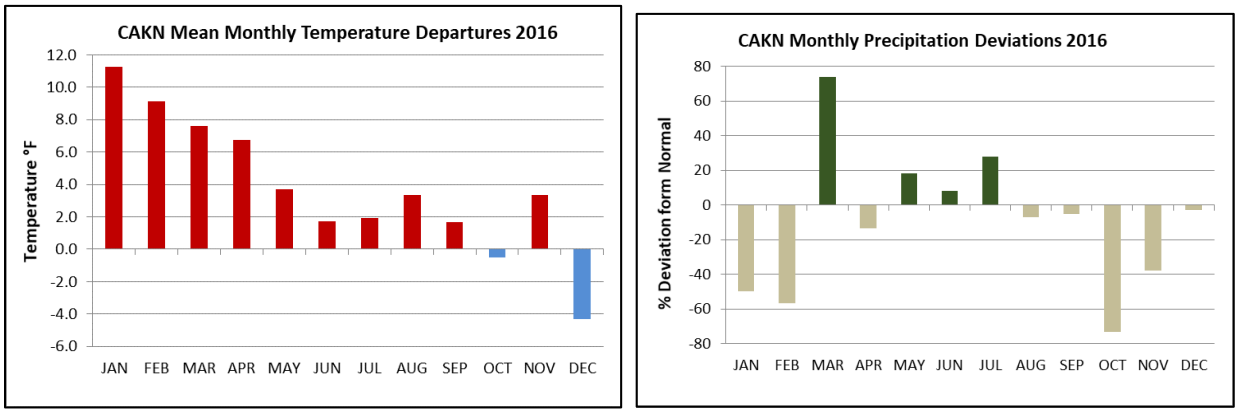

Figure3. Average monthly temperature departures (left) and monthly precipitation deviations (right).

Annual precipitation totals across the CAKN region varied from 78% of normal in Yakutat to 114% of normal in Denali and Eagle. January and February were much warmer and much drier than normal. Yakutat was the exception and was near normal in terms of the amount of late winter

precipitation, but unusual in that almost all of that fell as rain rather than snow. March was well above normal in terms of total precipitation, with snow coming after the climatalogical end of winter, which is the end of February. The summer months of June and July tended to be warmer and wetter, while August was drier than normal. October and November were much drier than normal (Figure 3 and 4).

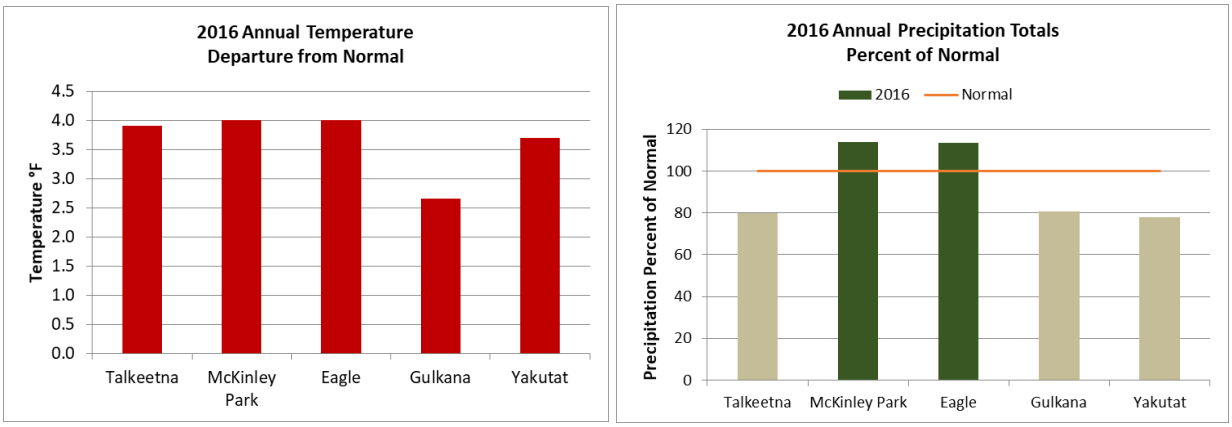

Figure 4. Average annual temperatures (left) and precipitation deviations (right) at the CAKN index sites.

CAKN RAWS Summary

2016 Temperatures

Last year we reported that the 2015 annual temperatures were the warmest on record in a decade of measurements, the year before we recorded 2014 as the warmest year on record; 2016 was warmer. All but two of the CAKN RAWS had the warmest annual temperatures on record in 2016 (records start in 2005 or 2006). The two exceptions were Coal Creek in YUCH and Chititu in WRST. Coal Creek was warmer in 2015 by 0.1°F and Chititu was warmer in 2014 by several degrees.

The mid-elevation sites were the warmest overall in the CAKN parks. The three warmest sites in 2016 were: Tokositna Valley, Eielson Visitor Center, and Ruth Glacier, respectively. Tokositna is a low-elevation site in the Cook Inlet climate division where temperatures are moderated by ocean temperatures to the south; temperatures in this region are warmer in the winter months. The other two warm sites are mid-elevation sites in the Alaska Range above 3,300' with much warmer winter temperatures than the surrounding lower elevation sites. These three sites are all in Denali.

The three coolest sites in 2016 were: Coal Creek, Chisana, and Upper Charley, respectively. Coal Creek and Chisana are low-elevation, valley bottom sites that are colder in the winter than most sites and are also subject to cold air pooling in the summer. The Upper Charley site does not get as cold in the winter, but spring, summer and fall temperatures are not as warm as other mid-elevation sites in the network. It is the farthest north mid-elevation site in the network (Figure 5).

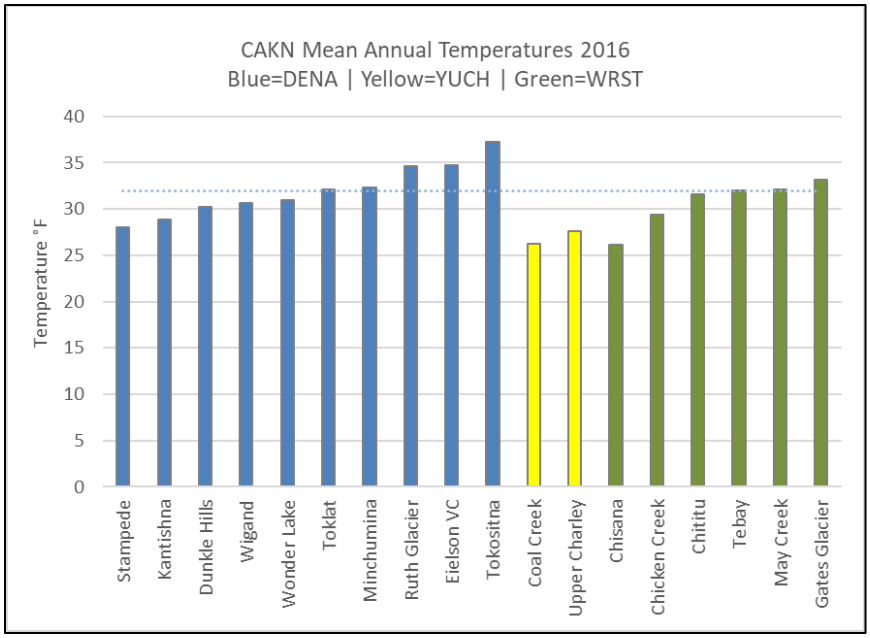

Figure 3. CAKN RAWS 2016 mean annual temperatures.

The mean annual temperature was above freezing at Eielson Visitor Center in Denali for 2014, 2015, and 2016. The period of record average annual temperature at Eielson is 29.4°F (2006-2016). Gates Glacier in Wrangell-St. Elias was also well above freezing for 2016; the mean annual temperature for the past decade averaged 28.8°F at Gates Glacier. The three recent warm years also brought annual temperatures at the sites in the Chugach Range in WRST near the freezing threshold. Tokositna and Ruth Glacier also have mean annual air temperatures above freezing; the two locations are within the Cook Inlet climate division where maritime influences moderate the temperature. The warm monthly temperature anomalies were a result of the warm North Pacific Ocean temperatures and the strong El Niño that affected most of the state.

Of the three CAKN parks, Denali stands out as being much warmer and much wetter than the other two parks in 2016. Figure 6 shows the trajectory of mean annual temperatures at a site in each of the three CAKN parks. The patterns are similar among sites; cold years, such as 2008 and 2012, tend to be cold region-wide and the same holds true for warm years although the absolute values differ depending on latitude and elevation.

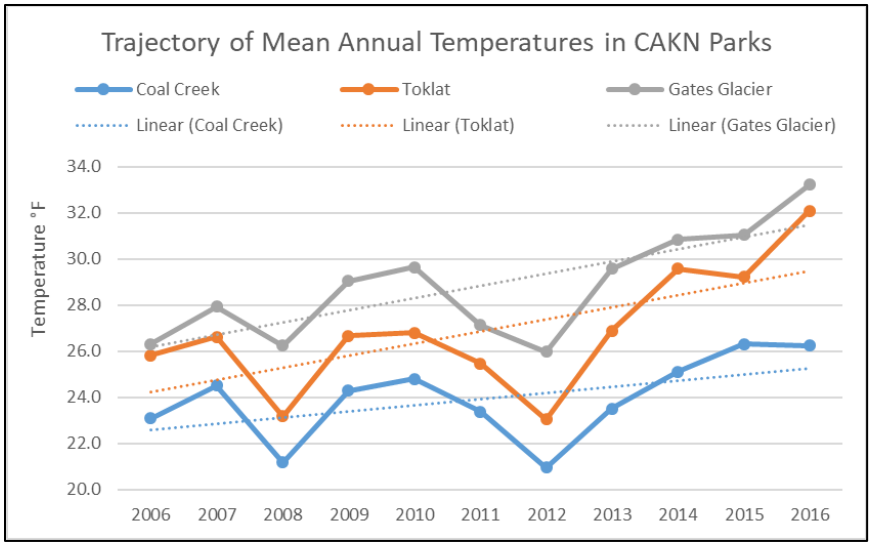

Figure 6. Trajectory of mean annual temperatures at three sites in the CAKN parks.

<u>Inversions and seasonal patterns</u>

The patterns and variability in monthly mean temperatures show up well when all of the CAKN RAWS sites are combined into one graph (Figure 7). Note the large variation in winter temperatures between sites versus other seasons. The sites that are warmest in the winter (mid-elevation sites) are generally the coolest sites in the summer. The variability tends to be much greater for winter temperatures, so the mid-elevation sites are much warmer than valley bottom sites in winter, but the valley bottom sites in summer are only marginally warmer than the mid-elevation sites.

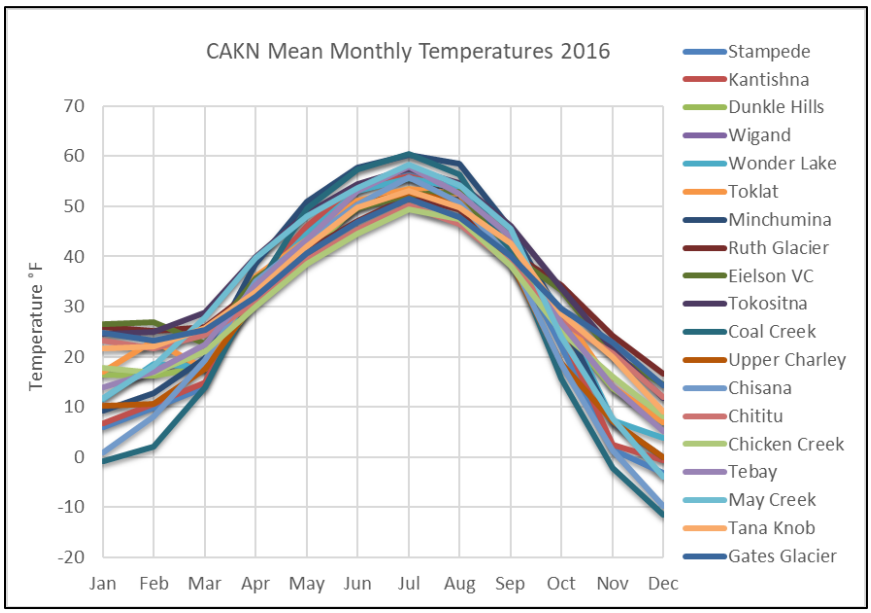

Figure 7. CAKN 2016 mean monthly temperatures.

In 2016, the variation in temperatures between sites for July, the warmest month, was ~ 9°F. December was the coldest winter month of 2016 and the range in temperatures between sites was ~28°F. Average July temperatures of all sites combined for 2016 was 53.0°F, ranging from 49.4°F at Chicken Creek in WRST to 60.4°F at Coal Creek in YUCH. For the warm January of 2016, the monthly average temperature for all sites was 14.7°F. The coldest site was Coal Creek with an average temperature of -0.9°F for the month, and Eielson Visitor Center was the warmest with an average monthly temperature of 26.4°F.

2016 Summer Rainfall

The CAKN sites have been operating for over a decade and this was the wettest summer on record at most of the sites in Denali. Most of the rain north of the Alaska Range fell in July. It was a wet August at Ruth Glacier, south of the range in DENA and at Gates Glacier in the Wrangell Mountain Range in WRST (Table 1).

Table 1. Summer rainfall totals at Denali and Wrangell-St. Elias 2016.

Site	June Total Inches	July Total Inches	August Total Inches	Summer Total Inches
Toklat	4.56	10.84	1.28	16.68
Eielson VC	5.98	16.66	2.56	25.20
Wonder Lake	4.94	10.11	3.19	18.24
Wigand	4.14	7.82	2.01	13.97
Stampede	3.69	6.56	2.43	12.68
Ruth Glacier	5.25	6.43	13.95	25.63
Gates Gl. (WRST)	2.06	5.50	12.40	19.96

2015-2016 Snow Season

In Eagle, the 2015-2016 seasonal snowfall was 61.3 inches, which is 98% of normal. The first day of persistent snow for the season was October 11 and the melt-out date was April 26. The McKinley Park long-term NWS site was just above normal with an annual total of 83.4 inches of snow. Snow on date was September 26, 2015 and the melt-out date was May 1, 2016. Snow is not recorded in Gulkana.

CAKN Snow Depth Sensors

Acoustic depth sensors on the CAKN RAWS measure the daily snow depth at the sites. Figure 8 shows the snowpack development through the 2015-2016 winter season at sites in WRST and YUCH. The valley bottom sites that are protected, such as Coal Creek in YUCH, and sites like Gates Glacier in the Wrangell Mountains that generally accumulate a significant amount of snow, clearly show the development of a snowpack (Figure 8). However, many of the CAKN RAWS are located above tree-line and those sites tend to have lower snow depths, more variability, and evidence of wind scour (Figure 9).

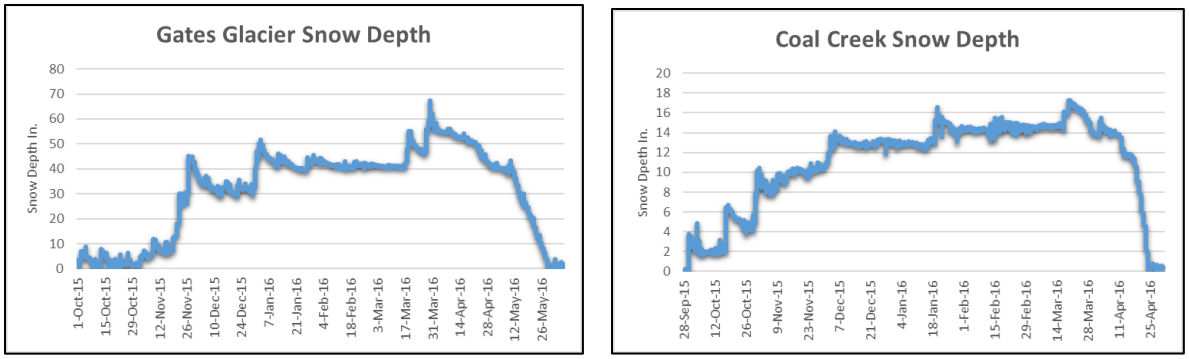

Figure 8. Snow depth at Gates Glacier in WRST (left) and at Coal Creek in YUCH (right).

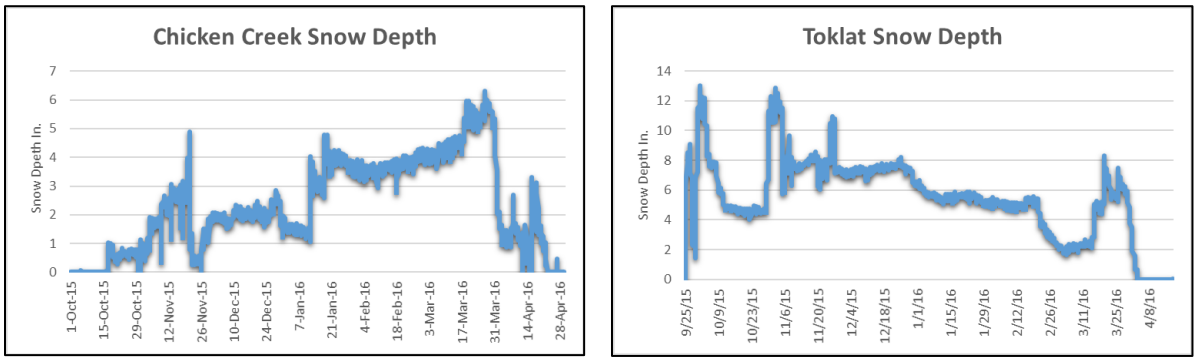

Figure 9. Snow depth at Chicken Creek/WRST (left) and Toklat/DENA (right).

<u>CAKN SNOTEL Sites</u>

For water year 2016, the Kantishna SNOTEL site recorded 5.0 inches of total winter precipitation (snow water equivalent) from October 1, 2015 through May 1, 2016. The total annual precipitation for the site was 29.3 inches; the winter snow accounted for 17% of the total annual precipitation. Snow-on date was September 15, 2015 and the snow-off date was April 30, 2016. The gauge at Tokositna Valley recorded 23.6 inches of precipitation from October 1, 2015 through May 1, 2016. This is 38% of the total annual precipitation of 62.8 inches for the 2016 water year (Figure 10). The snow on date at this site was October 28, 2015 and the snow off date was May 11, 2016.

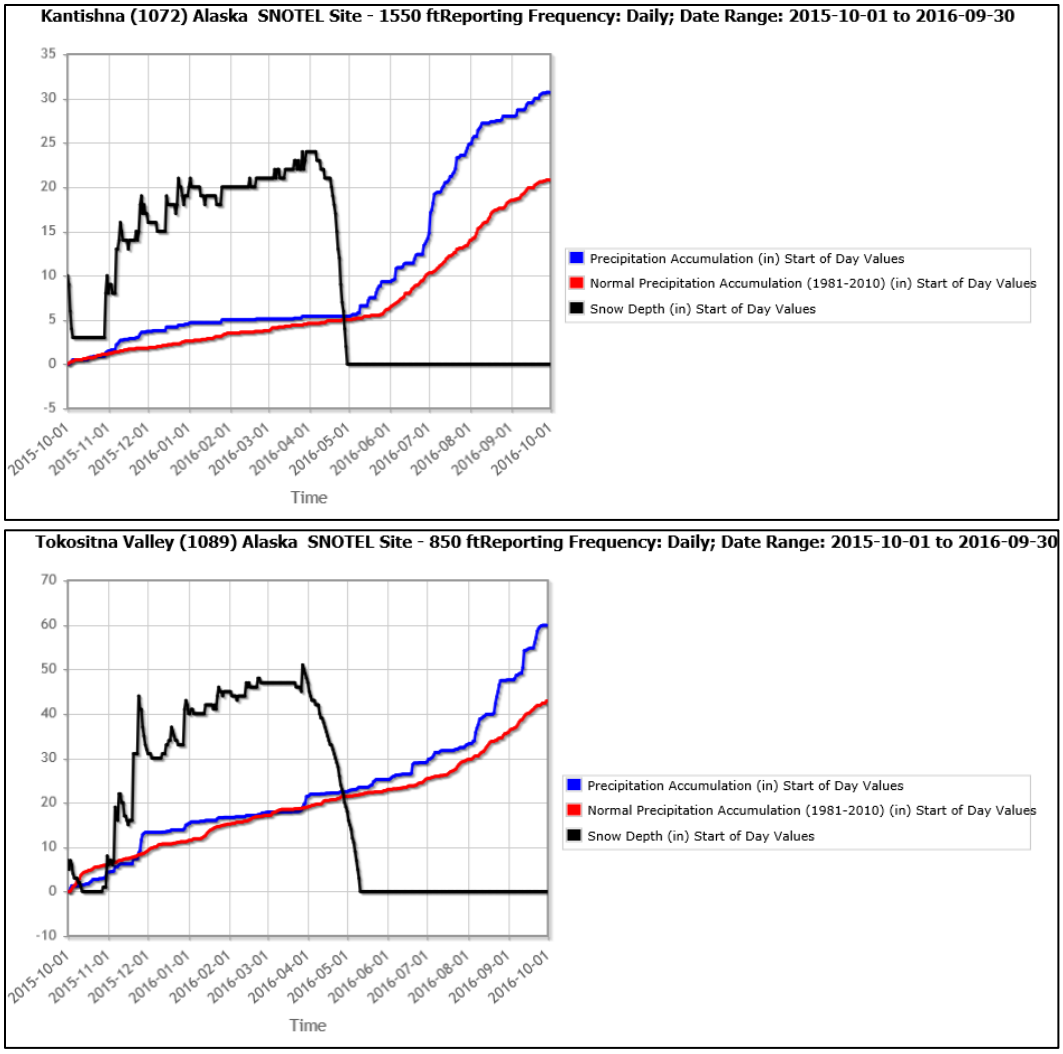

Figure 40. Cumulative precipitation for water year 2016 at Kantishna (top) and Tokositna Valley (bottom) in DENA (NRCS 2017b).

The SNOTEL site at May Creek reported 7.6 inches of snow water equivalent on May 1st; the annual total precipitation was 15.3 inches. The winter snowfall accounted for 50% of the total precipitation for the year. The snow-on date was October 3, 2015 and the snow-off date was April 20, 2016. The Chisana SNOTEL site recorded 3.7 inches of total winter precipitation from Oct 1 through May 1. The total annual precipitation was 11.1 inches; the winter snow accounted for 28% of the total annual precipitation for the 2016 water year. The snow on date was October 17 and the snow off date was April 22 (Figure 11). The record at the site is not long enough to calculate normals.

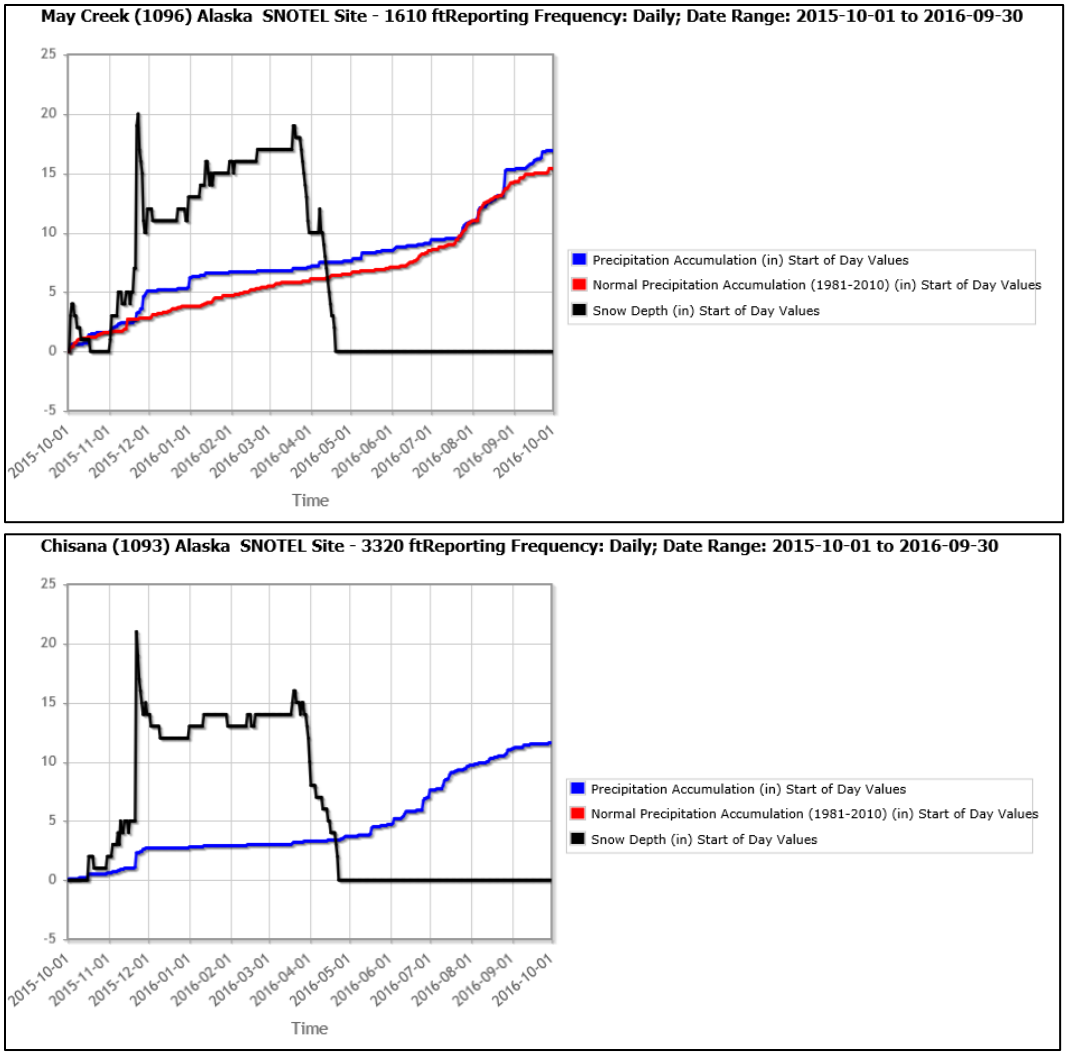

Figure 5. Cumulative precipitation for water year 2016 at May Creek (top) and Chisana (bottom) in WRST (NRCS 2017b).

The American Creek SNOTEL site near Eagle recorded a total of 3.8 inches of precipitation from October 1, 2015 through May 1, 2016. The total precipitation for the water year was 13.7 inches, the winter precipitation accounted for 28% of the annual total. The snow on date was October 10 and the snow off date was May 2, 2016. This site has a seven year record and therefore normal conditions cannot be calculated (Figure 12).

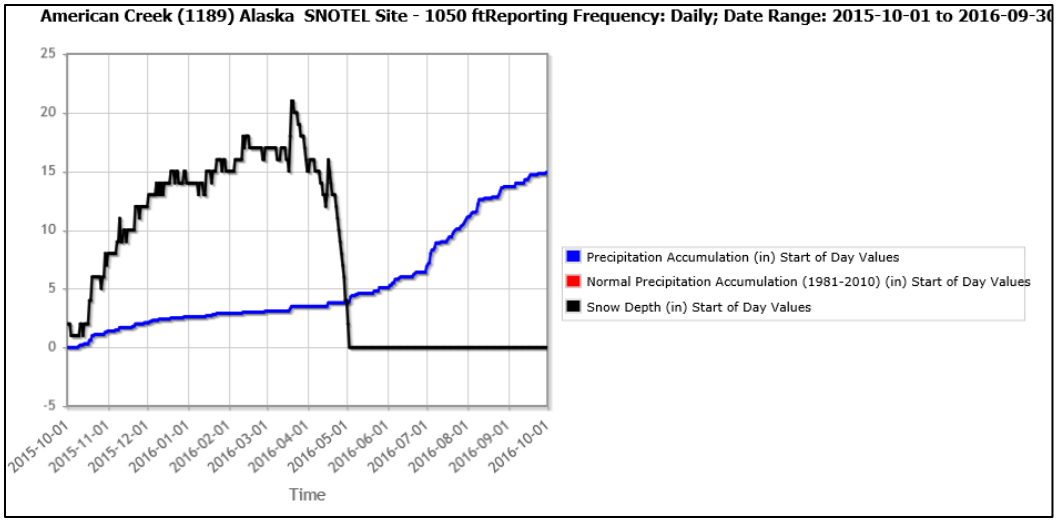

Figure 6. Cumulative precipitation for water year 2016 at American Creek near YUCH (NRCS 2017b).

Alaska Statewide Synopsis

According to National Oceanic and Atmospheric Administration (NOAA) 'State of the Climate' report for 2016, the average annual temperature for Alaska was 5.9° F (3.3° C) above the 1925-2016 average making 2016 the warmest year on record (NOAA 2017a). Overall, it was the 2nd warmest winter, warmest spring, 2nd warmest summer, and a warmer than normal fall for Alaska in 2017. The average annual temperature and precipitation ranks for the Alaska climate divisions are shown in Figure 13.

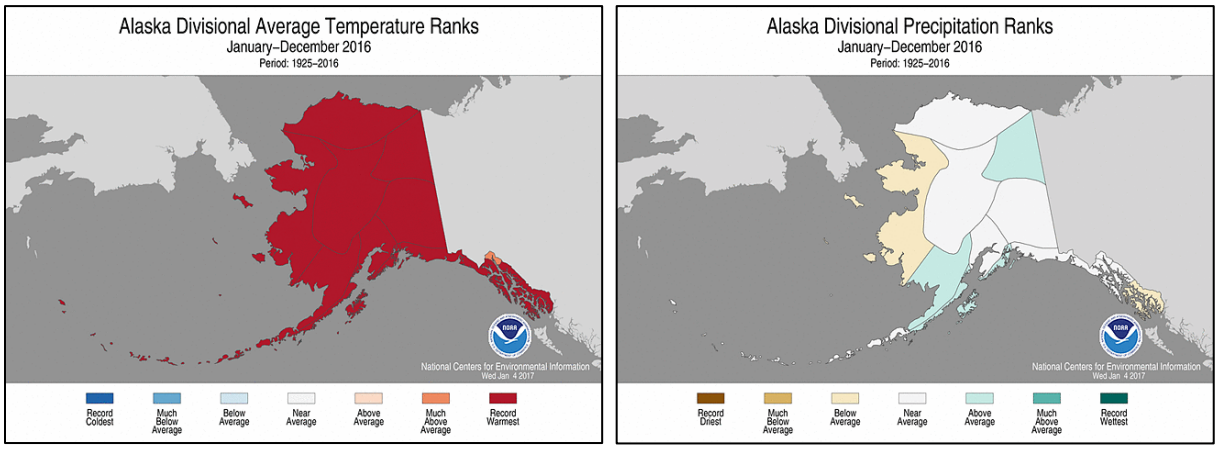

Figure 73. Average temperature (left) and precipitation (right) ranks for Alaska in 2016 (NOAA 2017a).

Precipitation statewide was about 4% below average with a mean total of 33.83 inches. Unlike temperature, large variations in precipitation occur over short distances. The northeast interior and southwest Alaska were wetter than normal, while the southeast and northwest coast of Alaska were below normal. It was a dry winter for most of Alaska, while spring was above average in terms of precipitation. Summer of 2016 was wetter than normal, especially June, July, and September, and the

fall period was well below normal in terms of precipitation. The 2015-2016 snowpack was ~ 50% of normal in many locations in the southcentral area of the state and well below normal in the southeastern areas of the state (Figure 14).

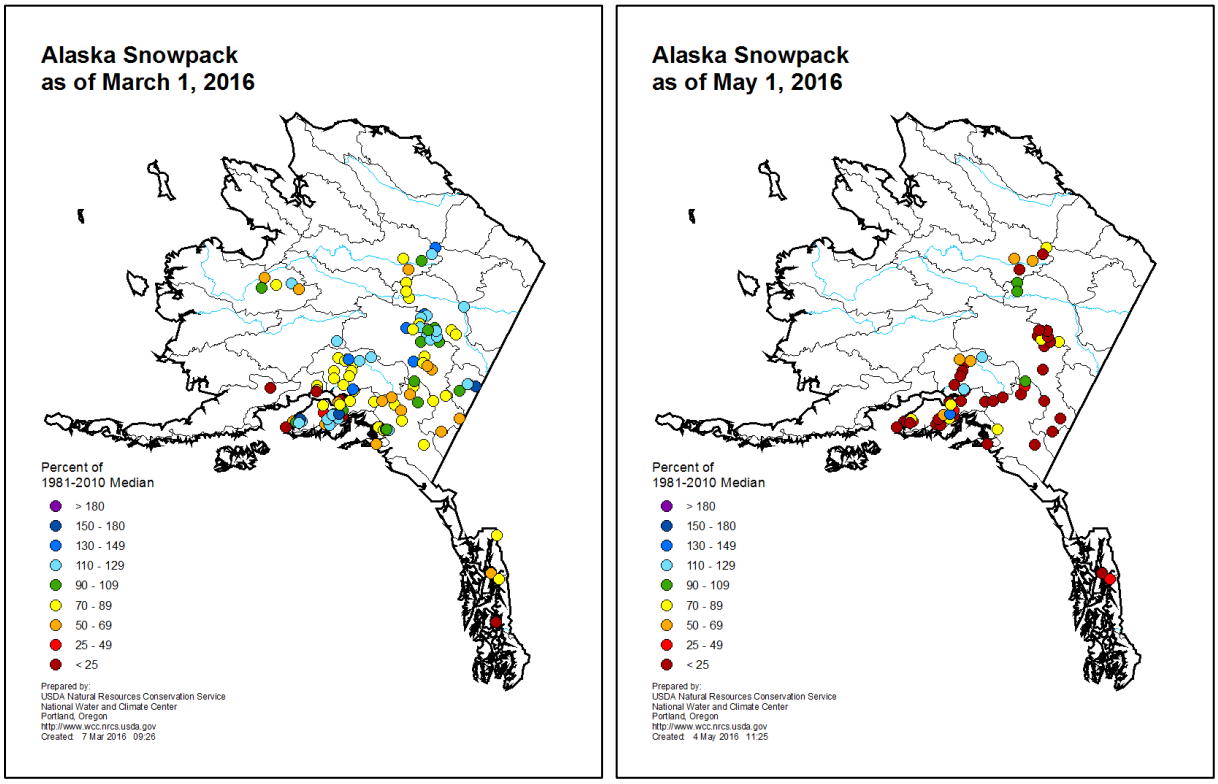

Figure 84. March 1 and May 1 snowpack percent of normal for Alaska 2016 (NRCS 2017a).

Wildfire Activity

According to the Alaska Interagency Coordination Center (AICC), a total of 558 wildfires burned 500, 095 acres in Alaska in 2016. This ranks as the 36th largest fire season (since 1939). This follows 2015 which was one of the busiest fire seasons in Alaska history and second in numbers of acres burned following 2004 with 6.2 million acres burned (AICC 2017). In 2016, the spring conditions were very similar to 2015 with low snowfall totals and a warm dry spring. June and July were wet this summer and that helped eliminate many of the starts. There were 22 fires that burned within the park boundaries and a total of 59,532 acres burned within and adjacent to the park boundaries (23,077 acres on NPS owned land). The total area burned within the CAKN parks was 24,735 acres this year, almost all of that within Wrangell-St. Elias (Barnes and Hrobak 2017).

Climate Teleconnections

The El Niño Southern Oscillation index was positive through the spring of 2016; the tail end of a strong El Niño that started in 2015. The PDO index was positive for all of 2016 and was consistently positive since January of 2014 (JISAO 2017). The Arctic sea ice extent in September 2016 was the second lowest extent in the satellite record, tied with 2007. The sea ice extent in 2016 was well below normal (NSIDC 2017) (Figure 15). The anomalous ‘blob’ of warm water in the North Pacific

Ocean persisted through October of 2016. Walsh et al. (2017) called the events of 2015-2016 the ‘perfect storm; that brought anomalously warm temperatures to mainland Alaska

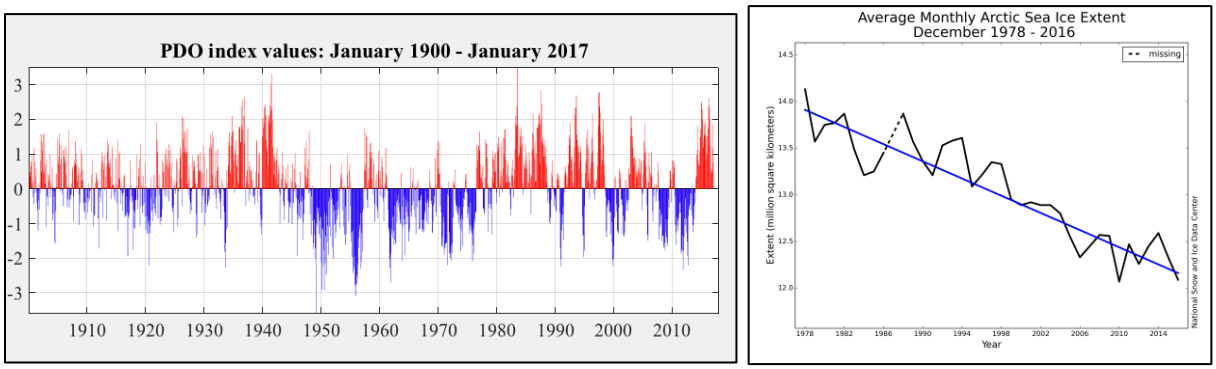

Figure 95. PDO index through January 2017 (right) (JISAO, 2017) and Arctic sea ice extent 1978-2016 (left) (NSIDC 2017).

National and Global Synopsis

Alaska’s warmest year on record was listed as one of the significant global climate anomalies of 2016. Based on data from January through December, the average annual temperature for the contiguous U.S. for 2016 was 54.9°F, 2.9°F (1.6°C) above the 20th century average. It was the 2nd warmest year over the 121-year record, 2012 was the warmest (NOAA 2017a). The average precipitation total for the lower 48 states in 2016 was 31.70 inches, 1.76 inches above average. This ranks as the 24th wettest year on record (NOAA 2017a).

Globally, 2016 was the warmest year on record. This is the third year in a row a new annual high global temperature record has been set. In 2016 it was 1.7°F (0.94°C) above the 20th century average of 57.0°F. The planet is now warming at a rate of 0.13°F per decade since 1880 and at a rate of 0.31°F per decade since 1970. There were extreme precipitation across the globes with many places with much more precipitation than normal and others in drought (NOAA 2017b).

Conclusions

2016 was the warmest year on record for Alaska. The mean annual temperature at the CAKN index sites averaged +3.6° F warmer than the 1981-2010 normal. Denali and Yukon-Charley were just above normal in terms of annual precipitation and Talkeetna, Gulkana, and Yakutat were all about 80% of normal. January and February were much warmer and much drier than normal. It snowed in the fall and it snowed in March, but there was little snow for the core winter months in 2015-2016. Spring was warmer than normal in most locations and the summer months of June and July tended to be warmer and wetter, while August was drier than normal. October and November were much drier than normal and December was the one month that was considerably colder than normal.

The climate data for 2016 was compiled and summarized using CAKN data from the NPS sites and from index sites around the region. Seasonal weather summaries are also produced four times a year for DENA, WRST, and YUCH and provide timely and relevant information on current weather statistics. These summaries are available from the network website or from the Integrated Resource Management Application (IRMA) portal.

The data from long-term sites are available from the National Centers for Environmental Information (NCEI) . The CAKN climate stations transmit data via satellite and are available on the web from MesoWest and the Western Regional Climate Center (WRCC). Products that are available include daily and monthly summaries, time series graphs, wind roses, data inventories, and station metadata for all of the automated stations. An interagency agreement is in place for the maintenance, data archiving, and data dissemination for the four SNOTEL sites in the network. The data from the stations are transmitted hourly via satellite and are available on-line at National Water and Climate Center.

This annual report provided a climate summary for the CAKN region in 2016 with brief references to the Alaska regional climate and the global climate for 2016.

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